Sexual Reproduction

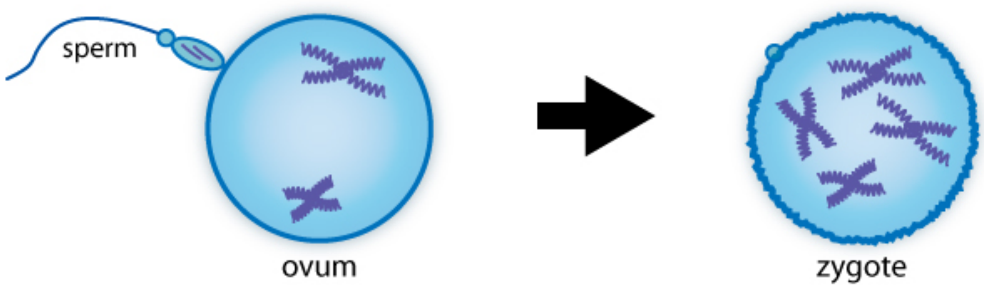
Recall that asexual reproduction involves only one parent cell. This parent cell divides to produce two daughter cells that are genetically identical to the parent.

Sexual reproduction, on the other hand, requires two different parent cells (e.g. a sperm cell and an egg cell). Also, sexual reproduction produces offspring that are genetically different from either parent.

The two parent cells needed for sexual reproduction are called **gametes**. They are formed during a process known as **meiosis**.

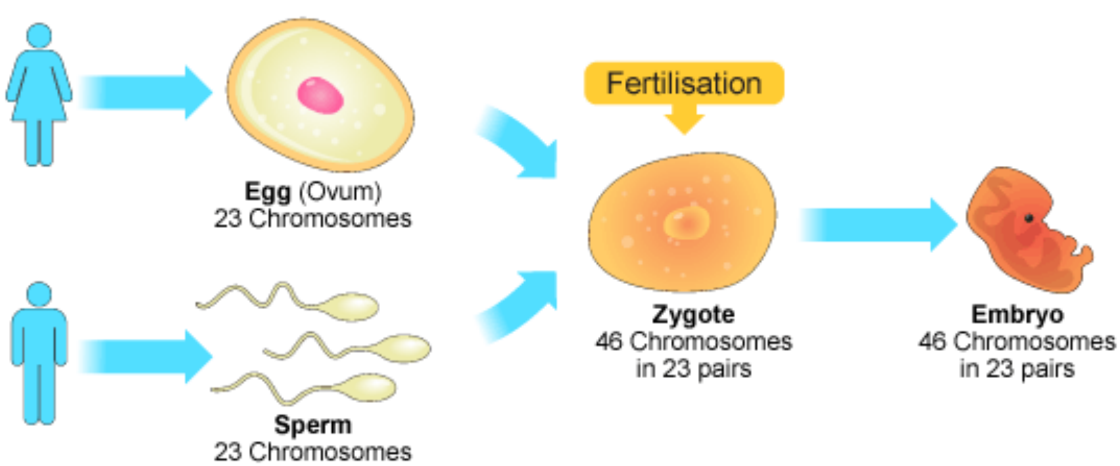
In animals, male gametes are called **sperm** cells, while female gametes are called **egg** cells (or **ovum**). In plants, "male" gametes are called **pollen**, while "female" gametes are called **ovules**.

A new offspring results when the male and female gametes fuse together in a process called **fertilization**. This process results in the formation of a single cell, known as a **zygote**.



In the picture above, you may have noticed that the gametes each have 2 chromosomes, while the zygote has 4. It turns out that gametes always have half the number of chromosomes that you would find in a normal cell. For example, a normal human cell has 46 chromosomes, but a human gamete (sperm or egg) has only 23.

Why is this necessary?



When a sperm cell (23 chromosomes) and an egg cell (23 chromosomes) combine, they result in a zygote with 46 chromosomes. If the sperm and egg had 46 chromosomes each, they would result in a zygote with 92 chromosomes, which would not be correct.

Cells that contain the full number of chromosomes for a species are said to be **diploid**. All cells except for gametes are diploid. Cells that contain only half the normal number of chromosomes for a species are said to be **haploid**. Gametes are haploid.

Meiosis

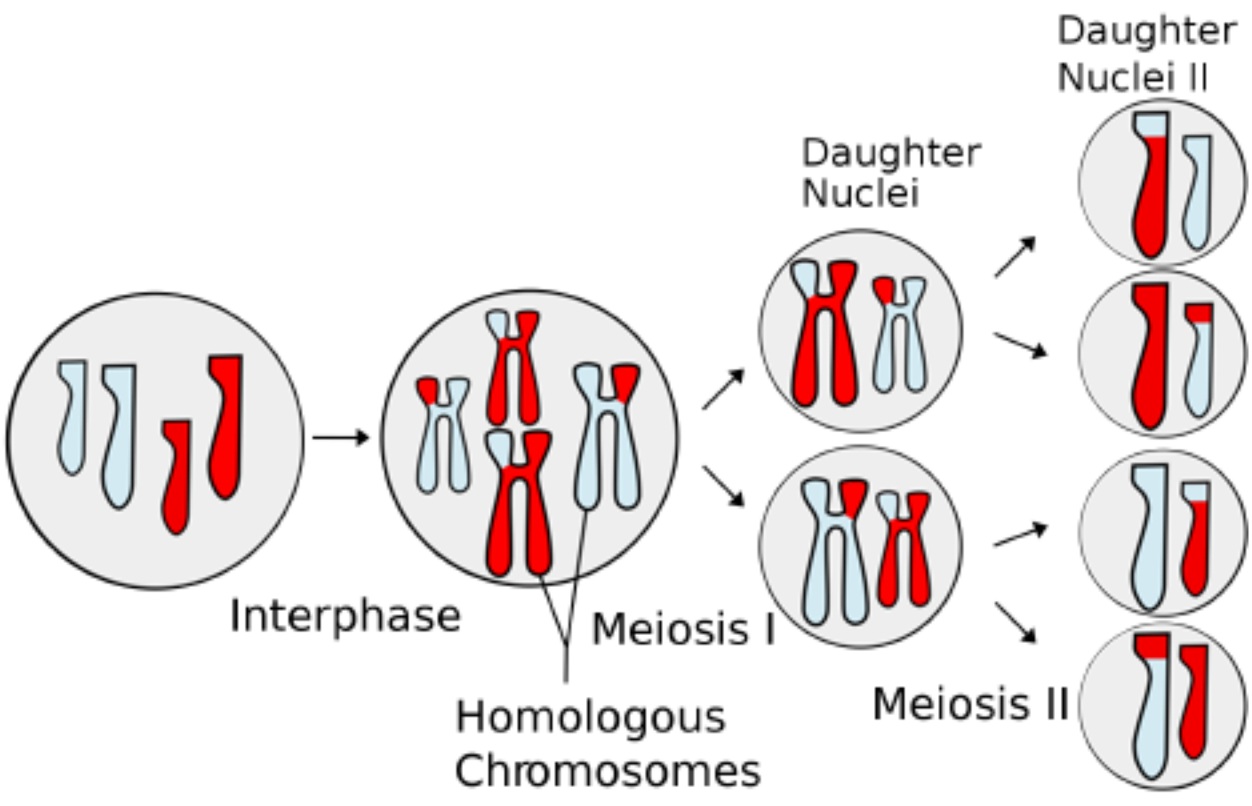
Meiosis is a special type of cell division that is responsible for the production of gametes. Meiosis is responsible for making sure that gametes contain half as many chromosomes as a normal cell.

While the process of meiosis is similar to mitosis in a number of ways, it has two major differences:

1. The chromosomes in meiosis undergo a "shuffling" that results in a different genetic combination in each gamete produced.

2. The outcome of meiosis is four haploid cells, while the outcome of mitosis is two diploid cells.

The diagram below provides an overview of the process of meiosis.



As you can see from the diagram, meiosis begins with a single diploid cell containing four chromosomes (if it was a human cell, it would contain 46). Notice that the chromosomes could be put into pairs based on size and shape (there are two long and two short). The chromosomes that make up a pair are called **homologous chromosomes**.

Phases of Meiosis

The phases of meiosis are summarized in the sections below. A diagram has been included at the end of these notes to illustrate the entire process.

Interphase

The steps that lead up to meiosis are the same as those that lead up to mitosis: growth and DNA replication. As with mitosis, these both take place during interphase.

At the end of interphase, as it prepares for meiosis, a human cell will contain 46 chromosomes arranged in 23 homologous pairs. Each chromosome will consist of two sister chromatids (the original chromosome and the copy).

Interphase is followed by meiosis I. **Meiosis I** consists of separating the pairs of homologous chromosomes, each made up of two sister chromatids, into two cells.

Meiosis I is further divided into four phases: prophase I, metaphase I, anaphase I, and telophase I. These phases are briefly described below.

Prophase I

- DNA is exchanged between homologous chromosomes in a process called crossing over. This process increases genetic variation between parent and offspring.
- The chromosomes condense and become visible. They also group themselves into homologous pairs.
- The centrosomes move to opposite ends of the cell.
- Spindle fibers form stretching between the centrosomes.
- The nuclear membrane disappears.

Metaphase I

- Homologous pairs line up along the equator of the cell.

Anaphase I

- One half of each homologous pair is pulled to each end of the cell by the spindle fibers.

Telophase I and Cytokinesis

- Nuclear membranes form around each group of chromosomes. Two nuclei are formed, each containing half of the original number of chromosomes (each of which is still attached to its copy).
- The chromosomes unfold back into chromatin and become invisible.
- The spindle fibers vanish.
- The cell divides to form two cells, each containing a single haploid nucleus.

Meiosis I is followed by meiosis II. **Meiosis II** consists of separating each chromosome's sister chromatids, and moving the individual chromatids into separate daughter cells. The two cells resulting from meiosis I divide during meiosis II, creating four daughter cells.

Meiosis II is further divided into four phases: prophase II, metaphase II, anaphase II, and telophase II. These phases are briefly described below.

Note: The phases of meiosis II occur in both of the cells formed during meiosis I.

Prophase II

- The chromosomes condense and become visible.
- The centrosomes move to opposite ends of the cell.
- Spindle fibers form.
- The nuclear membrane disappears.

Metaphase II

- The chromosomes line up along the equator of the cell.

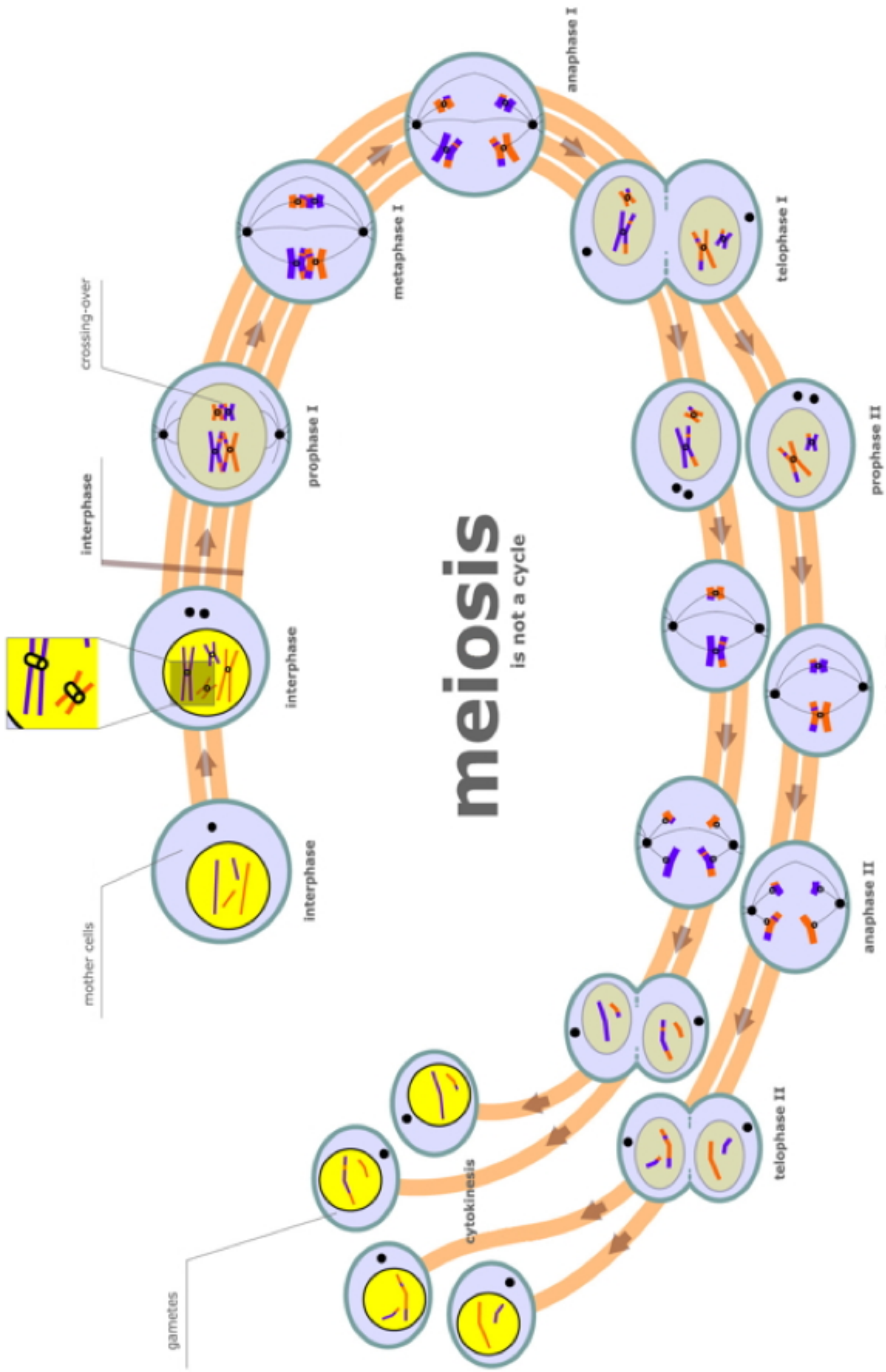
Anaphase II

- The centrosomes joining the sister chromatids together break.
- One half of each pair of sister chromatids is pulled to each end of the cell by the spindle fibers.

Telophase II and Cytokinesis

- Nuclear membranes form around each group of chromatids. Two nuclei are formed in each cell (four nuclei total), each containing half the original number of chromosomes (no longer attached to their copies).
- The spindle fibers vanish.
- Each cell divides to form two new cells (4 cells total), each containing a single haploid nucleus.

The four cells that are formed at the end of meiosis II are the gametes. Each gamete is haploid.


meiosis
is not a cycle
mother cells
interphase
interphase
interphase
crossing-over
prophase I
metaphase I
anaphase I
telophase I
prophase II
metaphase II
anaphase II
telophase II
cytokinesis
gametes